Extract from Debt and reserves management report 2012-13

Annex B

Quantitative analysis of debt service cost and risk

B.1. The DMO's Portfolio Simulation Tool (PST) model is used to provide estimates of the evolution over a five year horizon of cost and risk metrics of the gilt portfolio resulting from alternative debt issuance strategies.[1] Debt service cost is defined as the cost of the coupon payments and redemptions associated with government debt, measured in terms of the relevant yield.[2] Risk is defined as the standard deviation of debt service cost or debt service cost volatility. This can be thought of as a measure of the interest rate refinancing risk of the gilt portfolio.[3]

Table B.1: Gilt issuance strategy composition (per cent)

	Short conventional (0 – 7 years)	Medium conventional (7 – 15 years)	Long conventional (over 15 years)	Index-linked
Strategy 1	78	0	0	22
Strategy 2 2011-12 skew	34	22	23	22
Strategy 3	0	0	78	22

B.2. Debt service cost volatility is estimated by first deriving a lognormal distribution of nominal yields one year ahead from a large number of Monte Carlo simulations.[4] The yield distribution is then translated into a cost distribution by

[1] Described in detail in Chapter 6 of the *DMO Annual Review 2008-09*. See http://www.dmo.gov.uk/documentview.aspx?docname=research/PST_gar0809.pdf

[2] The yield curve model used in the PST is the Variable Roughness Penalty (VRP) model developed by the Bank of England and employed by the DMO since 2007. For more information on the VRP yield curve model see http://www.bankofengland.co.uk/statistics/yieldcurve/index.htm.

[3] Interest rate risk refers to the risk related to the financing of new debt, i.e. the CGNCR, whereas refinancing risk refers to the risk related to the refinancing of existing debt, i.e. refinancing of bonds that are redeeming.

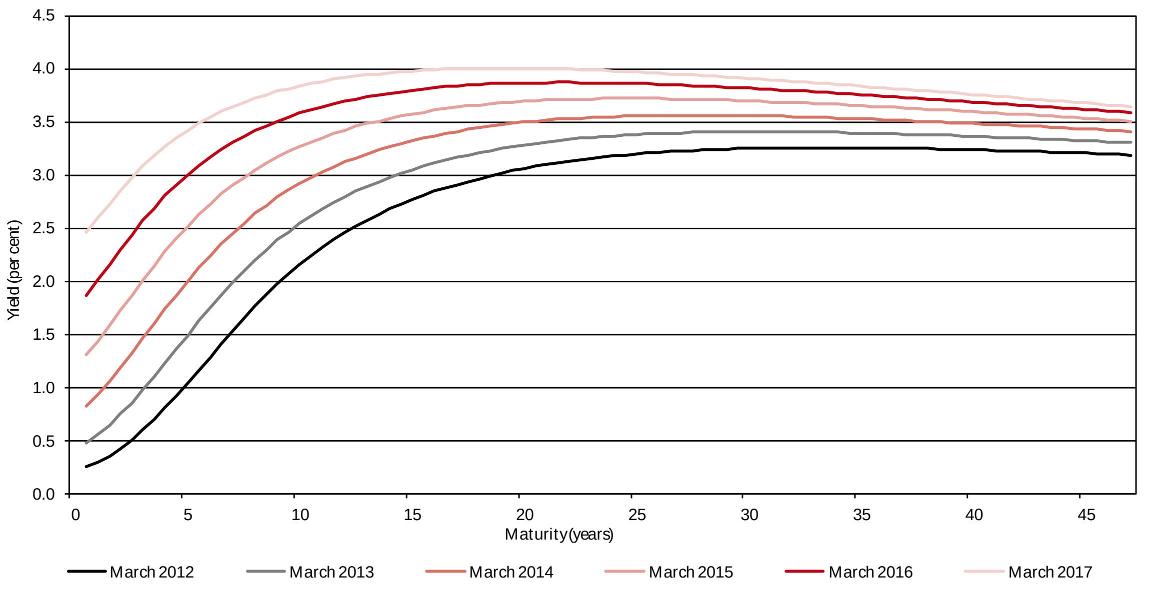
[4] In a lognormal distribution the underlying variable that is sampled is the natural logarithm of the variable itself. For example, if 'yield' is the variable, the sampling applies to log (yield). Use of this approach ensures that by construction the yield can never be negative. For real yields, a normal distribution (not in logs) is used in order to permit negative values in the simulation. Using a commercial risk management system, Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling to compute their results. In this case, the random sampling is drawn from a distribution of historical yield data from January 2000 to January 2011. The underlying model used for generating the Monte Carlo scenarios is a Black-Karasinski model of yields where the mean reversion parameters are estimated through Ordinary Least Squares (OLS) regressions using historical data between January 2000 and January 2008. It is worth noting that since the onset of the financial crisis in 2008, yields up to ten years

running the PST model for each yield curve simulated and calculating the resulting debt service cost. This process is repeated for each issuance strategy considered.

B.3. Table B.1 illustrates three issuance strategies. Strategies 1 and 3 represent two extreme issuance programmes with 100 per cent allocation to short and long gilt issuance respectively. Strategy 2 represents a split of issuance based on that in 2011-12, which is well diversified across maturity baskets with the highest allocation to short conventional issuance. All strategies have the same issuance split between conventional and index-linked gilts, 78 and 22 per cent respectively.

B.4. It is worth noting that the PST uses the implied nominal and real forward par yield curves for setting the coupons of new bonds issued over the five year simulation horizon. Chart B.1 shows a gradual flattening of the slope of the implied nominal forward curve over the five years of the simulation horizon, which will affect the relative cost-effectiveness of a given issuance strategy over the horizon considered.[5] In practice, of course, it is unlikely that future rates will coincide with the rates implied from the yield curve used in these simulations.

Chart B.1: Implied nominal forward curves each year of the simulation horizon



Source: DMO

Simulation results

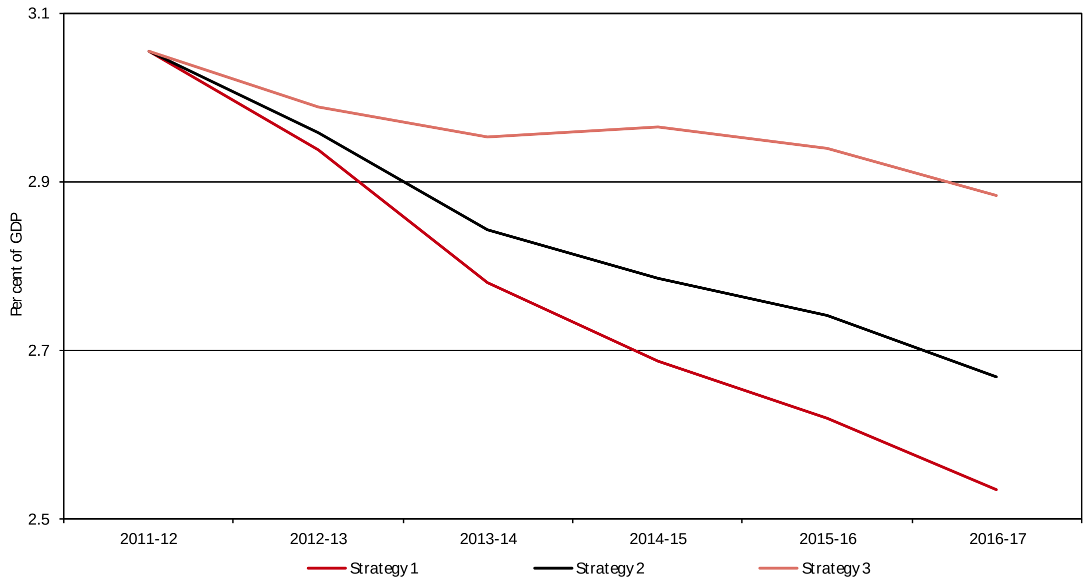
B.5. Debt service cost is shown in Chart B.2. The overall drop in debt service cost as a per cent of GDP during the simulation horizon is due to both the falling CGNCR as well as the projected increase in nominal GDP. Implementing Strategy 2 would

maturity have not been mean reverting due to historically low short-term interest rates. After considering alternative modelling options, the mean reverting model has been retained as the most appropriate despite its drawbacks.

[5] Yield data as of 8 March 2012.

result in debt service cost of around 2.7 per cent of GDP by the end of 2016-17. Strategy 1 is the cheapest issuance strategy whereas Strategy 3 is the most expensive, providing a floor and a ceiling respectively for debt service cost. The results when comparing the three strategies mainly reflect the upward sloping shape of the yield curve and historically low short-term yields.

Chart B.2: Debt service cost



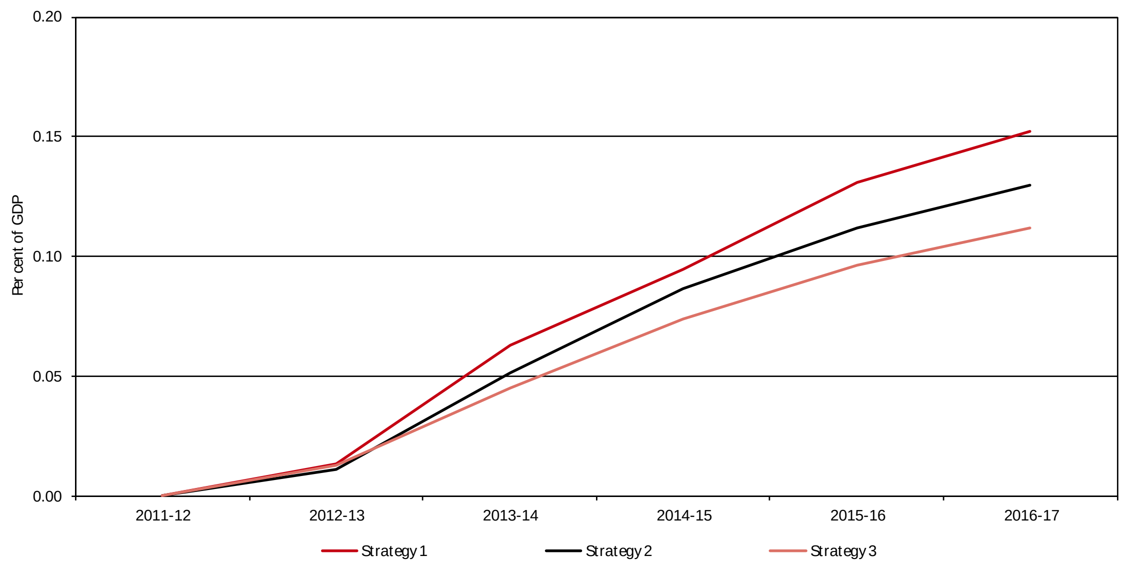
Source: DMO

B.6. The standard deviation of debt service cost, or debt service cost volatility, is shown in Chart B.3. Strategy 2 has a standard deviation of debt service cost of around 0.13 per cent of GDP by the end of 2016-17. It follows that the debt service cost of Strategy 2 may range between 2.5 per cent and 2.8 per cent of GDP by the end of 2016-17 with 68 per cent probability, reflecting potential yield movements.[6]

B.7. In comparative terms, the debt service cost volatility of Strategy 1 is the highest while that of Strategy 3 is the lowest, providing a ceiling and a floor respectively in terms of cost volatility. The volatility of debt service cost of Strategy 2 is roughly equidistant between strategies 1 and 3. These findings reflect the fact that short-term yields have historically been more volatile than long-term yields.

[6] For a normal distribution, the probability of values occurring within one standard deviation at either side of the mean of the distribution is of 34.1 per cent at each side. This means that the range of costs presented has a probability of occurring of just over 68 per cent.

Chart B.3: Standard deviation of debt service cost



Source: DMO

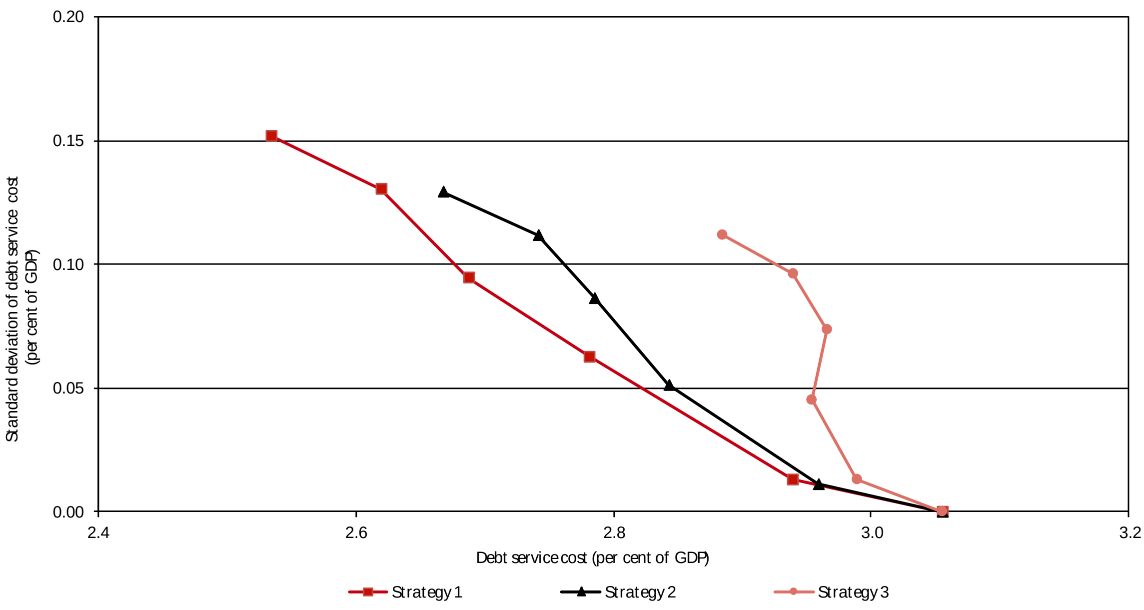
B.8. Chart B.4 shows a form of scatter plot obtained by combining the data from Chart B.2 and Chart B.3 and illustrates the simulated debt service cost and risk trade-off. Each point in the chart represents a financial year. The first point of the chart, representing 2011-12, depicts the same cost for all strategies and a standard deviation of zero, given that the financial year has finished in these scenarios and the actual cost of the debt portfolio has materialised.

B.9. The cost and risk trade-off in Chart B.4 indicates how much interest rate refinancing risk would be incurred for a given amount of cost when following each issuance strategy over the five year horizon. For example, taking the last point, which represents 2016-17, the cost of Strategy 1 is over 2.5 per cent of GDP with an interest rate refinancing risk of 0.15 per cent of GDP, whereas the cost for Strategy 3 is higher at around 2.9 per cent of GDP but has a lower interest rate refinancing risk of around 0.11 per cent of GDP. Strategy 2 would incur an interest rate refinancing risk of around 0.13 per cent of GDP, in between the two extreme strategies.

B.10. The relative comparison follows prior expectations given the assumption of an upward sloping yield curve.

B.11. Of all the strategies considered, Strategy 1 depicts the highest interest rate refinancing risk for a given cost because it needs to be refinanced more often. Strategy 3, which wholly comprises long-term issuance, needs to be rolled over less frequently and thus has the lowest interest rate refinancing risk of all the strategies considered, but the highest cost. Strategy 2 incorporates gilt issuance across a range of maturities and thus implies a more even trade-off.

Chart B.4: Simulated debt service cost and debt service cost at risk trade-offs



Source: DMO

B.12. It is worth noting that it is several years into the simulation before the cost and risk trade-offs of these strategies start to diverge significantly.[7] This is due to the large size of the existing debt portfolio relative to issuance, which induces inertia so that any changes in the structure of the debt portfolio resulting from issuance are slow to take effect. This feature can be depicted by the average maturity of the debt portfolio, historical and simulated, under the different issuance scenarios, as shown in Chart B.5.[8]

B.13. It is important to bear in mind some technical factors when interpreting the average maturity statistic. Firstly, the average maturity of the gilt portfolio as shown in Chart B.5 is weighted by market value. This implies that yield curve movements will affect the resulting average maturity of the portfolio regardless of issuance choices. For example, an upward move of 100 basis points of the entire yield curve will reduce the prices of longer-dated bonds proportionately by more than shorter-dated bonds, affecting the relative weighting in a way that reduces average maturity.

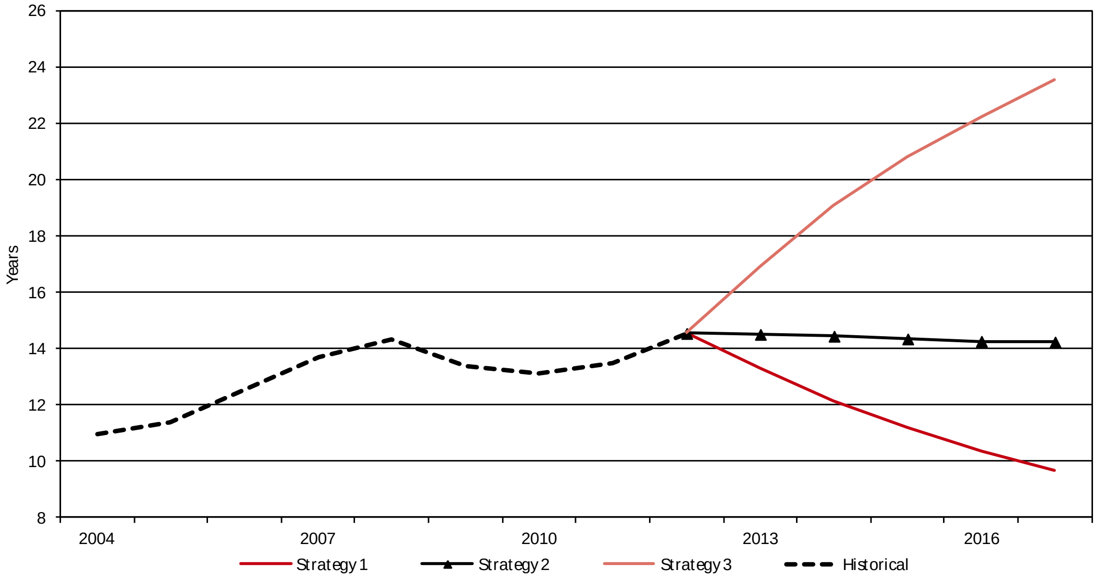
B.14. Secondly, there are portfolio effects to be considered. The natural tendency of the existing portfolio is for the average maturity to fall as time passes, i.e. portfolio ageing. As the gilt portfolio has become larger in recent years, and yearly issuance has become lower in proportion to the overall size of the portfolio, the impact of a given issuance skew on the overall average maturity is reduced. The redemption profile also matters when evaluating the effect of the issuance skew on

[7] In order to depict completely the cost and risk characteristics of each issuance strategy, a longer horizon that covers all cash flows up to the maturity of the longest bond should be considered. This is, however, beyond the scope of this analysis.

[8] Includes gilts and Treasury bills.

the overall portfolio and can manifest itself in irregular movements in the average maturity profile year-on-year.

Chart B.5: Simulated average maturity of the debt portfolio



Source: DMO

Conclusions

B.15. The quantitative modelling conducted by the DMO shows that a diversified issuance strategy offers a cost and risk trade-off which lies between that of an all-short issuance strategy – in which debt service costs are lower but debt service cost at risk is higher – and an all-long issuance strategy – in which debt service cost at risk is lower but debt service costs are higher.

The results of this model are presented to illustrate the cost and risk implications of pursuing theoretical 'extreme' issuance strategies relative to more balanced strategies. However, 'extreme' strategies would fail to take into account a broad range of factors including: relative cost-effectiveness of different maturities and types of gilt, demand, consideration of other risks, operational and practical considerations.[9] Therefore, in reaching its decision the Government has favoured a more balanced strategy that takes into account these factors.

[9] See the first section of this annex.